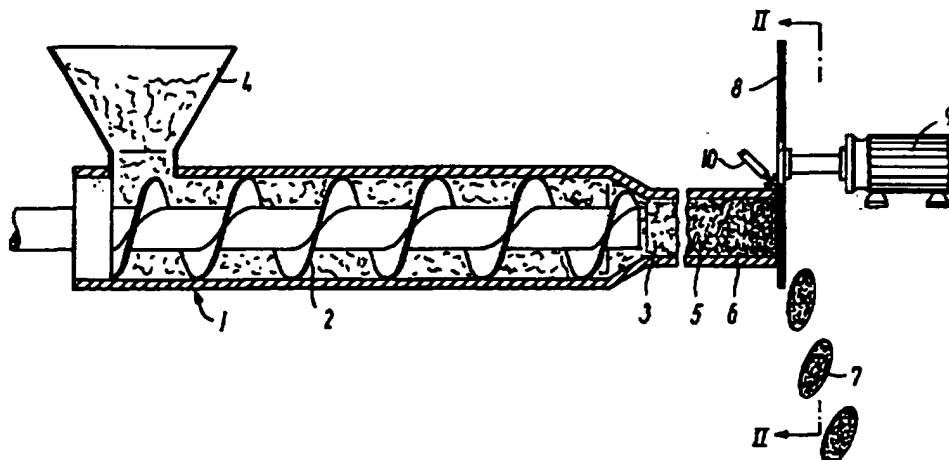


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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/DK95/00393 (22) International Filing Date: 29 September 1995 (29.09.95)  (30) Priority Data: 1148/94 4 October 1994 (04.10.94) DK  (71)(72) Applicant and Inventor: PEDERSEN, Bjørn [DK/DE]; Førdebogen 33, D-24955 Harrislee (DE).  (74) Agent: HOLME PATENT A/S; Sankt Peders Stræde 41, DK- 1453 Copenhagen K (DK).		(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).  <b>Published</b> <i>With international search report.</i> <i>With amended claims and statement.</i> <i>In English translation (filed in Danish).</i>

(54) Title: A CARRIER MEDIUM TO RETAIN A BIOFILM FOR CLEANING WASTE WATER AND A PROCESS FOR THE PRODUCTION OF THIS CARRIER MEDIUM



## (57) Abstract

A carrier medium serves to retain a biofilm in a fluid, e.g. waste water. The carrying medium consists of a number of thin disc- or ring-shaped flakes (7) of a relatively hard plast material which is mixed with a foaming detergent in form of a granule or a powder. The mixture is led to an extruder (1) and heated such that the plast material is brought into a plastic condition while the foaming detergent is foaming and is filling the material with cells under gas overpressure. The foamed plast material is thereafter extruded from the nozzle (3) of the extruder to a bar (5) which in a tube (6) is cooled to a partly plastic condition and cutted into discs or flakes (7) which are so thin that at least a great part of the cells between the cuts are bursted by the gas overpressure, whereby arising an extremely large number of pores (11) causing the carrying medium to obtain a much larger surface than known hitherto and a corresponding larger cleaning effect. The carrying medium is furthermore able to secure a controlled activity in the biofilm without any risk for taking place at the same time an aerobic and an anaerobic reaction, and the carrying medium is durable even during a long stay in a fluid stream.

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A Carrier Medium to Retain a Biofilm for Cleaning Waste Water and a Process for the Production of this Carrier Medium.

This invention relates to a carrying medium to retain a biofilm in a fluid, e.g. waste water, comprising a number of carrying elements having close-set pores.

- 5 Such a carrier medium is known from e.g. the published DE application No. 40 22 552 A1 which describes a porous filtermaterial which can be of hard materials, such as clay, glass, foamed glass (German: Schaumglas), perlite, stoneware, ceramics, porcelain and quartz, and a stiff and hard plast  
10 material also can be used. The mentioned filter material has pores in form of capillary tubes which have the effect of obtaining, at the same time, a not wanted uncontrollable aerobic and anaerobic reaction.
- 15 From the lay open publication DK No. 152590 B is known another carrying medium which consists of stainless steel, certain synthetic types of plast, or glass and other non corrosive materials in form of elements with a mainly netformed inner structure. In none of the three dimensions of the space these  
20 elements have a relative small extension and they therefore can contain a deep coherent biomass inside the net structure, whereby uncontrollable aerobic as well as anaerobic reactions can take place.
- 25 In the patent specification GB 1,034,760 an aerated filter for biological cleaning of waste water is described. The filter is constructed of packed elements in the form of e.g. balls, cubes, rings, tubes, cones, gratings and nets. For the production of these elements, an inactive expanded polymeric  
30 materials is used, e.g. polyurethane, polyvinylchloride, polystyrene, polypropylene or polyamide. The material can be stiff to make the packed filter sufficiently selfcarrying, and in all instances the elements must have such a form that they can be packed to a filter in a way leaving free passage for  
35 air and liquid through the filter. This excludes that the elements can have form of flat discs which by packing would

place themselves on top of each other in a pattern which totally or partly would block the passage through the filter.

Further it is to be assumed that the filter elements for being  
5 able stable to support each other in one or more areas, while,  
at the same time, there moreover must be a sufficiently large  
distance between the elements for allowing the filter to  
function effectively, they need to have such a large spacious  
extension that there, as in the previous case, will be formed  
10 a deep coherent biomass where both aerobic and anaerobic  
uncontrolled reactions can take place.

The same is the case for the medium to carry a biofilm known  
from the European patent application No. 0 302 965 A2, as this  
15 carrier medium consists of an extruded bar that can be divided  
into cylindrical or cubical elements having about the same  
extension in all three of the dimensions. The material used is  
mainly based on burned diatomite with an additive of inorganic  
binder, burned out organic materials, an organic polymeric  
20 aid, an organic solvent, like kerosene, diesel oil, alcohol or  
melted wax. The finished material contains a porosity as  
mainly is coming from the used diatomite and it is relatively  
fragile and vulnerable and therefore unsuitable for serving as  
loose elements in a fluid stream where the elements constantly  
25 will be inclined to come into collision and rub against each  
other in a way as they will not be able to stand.

The object of the invention is to disclose a carrier medium of  
the type mentioned in the opening paragraph having carrying  
30 elements as can safely retain a biofilm, as is durable during  
even a long time staying in a fluid stream, as in proportion  
to the volume has a larger surface than known hitherto and a  
corresponding higher effect of cleaning, and as is able to  
secure a controlled activity of the biofilm without any risk  
35 for a simultaneous aerobic and anaerobic reaction.

This is, according to the invention, obtained by forming the carrying elements as thin discs- or ringshaped flakes of a relatively hard material. These flakes have a very large easily accessible surface upon which the micro-organisms of  
5 the biofilm can be fixed. The porosity's have form of low grooves which at a maximum can have a thickness corresponding to the indentations of the pores causing, as the flakes are thin, that there cannot - as in the carrying medium known - be created a deleterious or unwanted capillary effect.

10

The micro-organisms are in relation to the passing stream of water sheltered by the low indentations on both sides of the flakes whereby the biofilm can be kept in peace even under very strong turbulence and pulsation in the water. This makes  
15 it possible to establish a culture of fixed and easily accessible micro-organisms in a hitherto unknown scale and the created biofilm will, owing to the protected shelter position, be able to regenerate relatively fast by an eventual accident.

20 As the biofilm is in the low grooves the film it is so thin that a direct contact with the waste water, the content of this and the air is secured. The distance between a micro-organism and the water cannot be larger than half thickness of the flake, i.e., by way of example, 0.3 mm by a  
25 0.6 mm thick flake.

This short distance moreover entails the advantage that there cannot or only with difficulty occur anaerobic conditions behind an aerobic biofilm as the biofilm is so thin that  
30 oxygen will diffuse through the film and destroy an eventually beginning anaerobic condition.

Thereby the total area, upon which the biofilm is fixed, is fully utilised for the purpose wanted, whereby the area of the  
35 carrying medium as is at the disposal for the cleaning process is optimally utilised. The cleaning process will moreover

become biologically controllable which is very advantageously by, among other things, industrial fermentation.

The short distance between the micro-organisms and the content  
5 of the waste water furthermore facilitates the cleaning  
process which, to a great extent, relies on the activity of  
the micro-organisms or how good the diffusion through the  
cellwall takes place. The proportions of this diffusion is  
increased when the micro-organisms are coming in the best  
10 possible contact with the waste water to be cleaned or, in  
other words, when the microfilm is in the porosity's of the  
flakes.

Flakes placed in e.g. waste water can in eventual dependence  
15 of the proportions of the growth have a larger or lesser  
density than this waste water. In both cases the flat flakes  
will seek towards each other under influence of the passing  
stream of water. The water must therefore traverse a far  
longer way than will be the case when e.g. ball or cubic  
20 formed elements are used. Thereby increasing the cleaning  
capacity of a cleaning module having a given volume.

A biofilm has a tendency to grow immoderately. To avoid this  
the flat flakes are, according to the invention, produced of a  
25 hard material. Acted on by the waste water flowing through and  
by the injected air the flakes will hit each other and rub  
against each other whereby the surplus of biomass  
advantageously is scraped off owing to the hardness of the  
flakes.

30

The invention also relates to a process for production of the  
above mentioned carrying elements of a plast material in the  
shape of a granulate or a powder which is mixed with a foaming  
detergent, whereafter the mixture is led to an extruder and  
35 heated in such a way that the plast material is brought into a  
plastic condition while the foaming detergent by foaming is

filling the material with cells under a gas overpressure and the foamed plast material then is extruded from the nozzle of the extruder to a bar cooled to a partly plastic condition and cutted up into discs so thin that, at any rate, a great part  
5 of the cells behind the cuts are bursted by the overpressure of the gas.

When a foaming detergent initially has been added to the plast material this is during the extrusion filled with small closed  
10 cells, some of which are, in dependence of the pressure and the temperature, on the way through the extruder assuming form of elongated ellipses extending in the longitudinal direction of the bar. Other cells will be more or less spherical.

15

When the cut discs are sufficiently thin the knives will to a great extend cut the elongated cells transversely, thereby open them, while the numerous about spherical cells between the cuts not at the same time will be cut through and opened.

20

When the plast material has been cooled to a temperature where it can be cut into thin discs, but not yet has obtained its full strength, and the foaming detergent has created a sufficient overpressure in the closed cells, these will be  
25 inclined to burst and open towards the surface or e.g. the already opened longitudinal cells.

In this way is obtained a total surface which is very much larger than the surface of the conventional carrying medium.  
30 The surface furthermore consists of pores which mostly debouch perpendicular into a free surface where the biofilm therefore can obtain the greatest possible effect of shelter.

The invention will be explained more fully below with  
35 reference to the drawing, in which

Fig. 1 is a view, seen from the side, of an arrangement where an extruder is producing a foamed plast bar which is cutted into thin discs which form the carrying medium according to the invention.

5

Fig. 2 is a view of the same, seen after the line II - II in figure 1.

Fig. 3 is in a larger scale a perspective view of a cutted  
10 disc according to the invention.

Fig. 4 is cross sections taken through a number of the disc shown in fig. 3, freely floating in the passing waste water to be cleaned.

15

In fig. 1 is seen an extruder 1 having a worm 2, a nozzle 3, and a funnel 4 for filling with a plast material mixed with a suitable foaming detergent.

20 When the extruder is working the mixture is heated by a heating means, not shown, and extruded from the nozzle 3 of the extruder in form of a bar 5. This bar is outside the extruder supported by e.g. a tube 6 and at the end of this tube cutted into thin discs 7 by means of, in this case, four  
25 rotating knives 8 which are driven by a motor 9. To obtain a clean cut the knives are sprayed from a nozzle 10 with e.g. alcohol cooling the knives and acting as a lubricant in the cut. In stead of this arrangement the knives can pass through an underlying vessel containing the cooling lubricant.

30

As mentioned the plast material is heated in the extruder such that it is brought into a plastic condition causing it to be workable in the extruder and to be formed to a bar in the nozzle.

35



At the same time the foaming detergent is foaming the plast material whereby forming in this a very large number of small, closed, initially about spherical cells which are filled with a gas having a higher pressure than the pressure of the ambient environments, i.e. more than about 1 bar.

Some of these cells are, during the working in the extruder, squeezed together and are leaving the nozzle in form of elongated elliptical tubes while other cells, to a larger or lesser extent, keep their originally spherical form.

On the stretch from the nozzle to the knives the bar in the tube 6 is cooled to a temperature where the bar is sufficiently hard to stand a cutting into thin discs.

15

The temperature is not lower, however, than the bar still has a partly plastic condition and those cells, which has not been cutted by the knives, as is the case for most of the elongated cells, therefore are bursted by the overpressure in the cells which thereby open towards the open air or towards one or more of the cutted cells.

Fig. 3 illustrates a singular cutted disc 7 and shows how the pores 11 are juxtaposed close-setted all over the surface of the disc.

The thickness of the discs can advantageously be between 0.1 and 2 mm whereby the biofilm in the indentations of the flakes all advantageously obtain a very small distance to the waste water to be cleaned and to the air contributing to this process.

Advantageously the flakes furthermore can be roundish having a diameter between 2 and 50 mm.

35

Fig. 4. illustrates how the waste water is streaming past a number of discs which, owing to their thin, flat form, will be inclined to place themselves side by side in the water, thereby forming a large number of narrow passages which force the water to traverse a very long way of streaming. The water and the impurities in this thereby obtain a prolonged and intimate contact with a large amount of micro-organisms, whereby a cleaning module having a given volume is secured a very much larger cleaning capacity than known hitherto.

10

For more explicitly to elucidate the effect of the carrying medium in relation to known carrying medium tests were carried out based on the following specification:

15 Raw material:	Polyethylene (PE)
Type/Form:	Circular, porous disc
Diameter :	about 20 mm
Height :	about 1 mm
Number of pieces/m <sup>3</sup> :	about 830.000
20 Weight:	about 280 kg/ m <sup>3</sup>
Specific density:	about 0.65 g/cm <sup>3</sup>
Surface:	about 120.000- 150.000 m <sup>2</sup> / m <sup>3</sup>

In two series of experiments the carrying medium, according to the invention, was tested partly in comparison with other carrying medium and partly in comparison with a reactor without carrying medium.

The experiments took place in three pieces of 3 l glass reactors which were aerated from below with pressured air via a perforated plate, and the reactors were continuously filled from a store-container to which the treated water was recirculated. The waste water was taken from a municipal purifying plant, and each of the experiment reactors was inoculated with 100 ml micro-organisms containing sludge.

Analysis were continuously carried out for:

- Demand of Oxygen
- Ammonium
- 5 - Nitrate and Nitrite
- pH-value

#### Experiment 1

- 10 In this experiment was tested which influence the carrying medium, according to the invention, had on the cleaning effect of municipal waste water, compared partly with another carrier medium consisting of a particularly burned porous clay and partly without any carrying medium.

15

Reactor 1.1: Particularly burnt porous clay  
Volume: about 1 litre

20

Reactor 1.2: Plast carrying medium according to the  
invention  
Volume: about 1 litre

25

- The initial concentration of the oxygen demand of the waste water was between 1.000 and 1.260 mg O<sub>2</sub>/l, and the initial concentration of the ammonium content was about 52 mg/l. After 4 days of experiments the oxygen demand was strongly reduced
- 30 in all three of the reactors. No significant difference of the oxygen demand was noted between reactor 1.1 and 1.2 as reactor 1.1 had reduced the oxygen demand with 77 % and reactor 1.2 with 68 %.

- 35 The nitrification, i.e. the decomposition of ammonium, was in all cases finished in 7 days. In the first 4 days the reactor

with the plast carrying medium of had a remarkably larger reaction, as the ammonium content in reactor 1.2 was reduced with 53 % while only with 28 % in reactor 1.1.

- 5 Such this series of experiments has proved that the large surface of the carrying medium, according to the invention, does not produce any directly advantage concerning the reduction of the oxygen demand, but facilitates, on the other hand, the nitrification to a considerable extent.

10

### Experiment 2

This series of experiments serves to answer the following questions:

15

a) Does the larger surface of the carrying medium, according to the invention, cause the expected larger cleaning effect in proportion to other carrying medium with lesser surfaces?.

- 20 For this purpose there was used 330 ml plast carrying medium, according to the invention, and 1.000 ml particularly burned porous clay, respectively.

b) Has the specific form and the choice of material of the  
25 carrying medium, according to the invention, a positive effect on the capability of the compressed air to create turbulence in the reactor ?.

Reactor 2.1:            Particularly burned porous clay  
30                            Volume: about 1 litre

Reactor 2.2            Plast carrying medium, according to the  
                          invention  
                          Volume: about 330 ml

35

The initial concentration of the waste water:

- Demand of Oxygen	700,00 mg O <sub>2</sub> /l
- Ammonium	30,00 mg/l
- Nitrate	24,00 mg/l
5 - Nitrite	0,86 mg/l
- pH-value	7,6

After 4 days the oxygen demand was strongly reduced in all three of the reactors such as appearing from the following  
10 procentisk statements:

- particularly burned porous clay (reactor 2.1) 75 %
- PE - medium (reactor 2.2) 74 %

15

This result proves that there are no significant difference between the reactors concerning the reduction of oxygen demand.

20 It is however worth noting that a reduction of the plast carrying medium to 1/3 of the volume of the other carrying medium did not have any noticeable influence on the effect of cleaning, such that, concerning the demand of oxygen, there consequently can be obtained the same result as obtained with  
25 the other carrying medium but with a considerable smaller consumption of volume of the carrying medium, according to the invention.

Regarding the nitrification, after the first 6 days the  
30 reactor filled with the plast material, according to the invention, had a significant better efficiency such as appearing from the following results.

- Particularly burned porous clay (Reactor 2.1) : no reaction

35

- Plast carrying medium, according to the invention (reactor 2.2) : 99.5 %

Also by this experiment the larger specific surface of the  
5 plast carrying medium had proved to be of lesser importance  
concerning the reduction of the oxygen demand, while the  
decomposition of ammonium to nitrite and nitrate, on the other  
hand, proved to have an even very large effect.

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## C L A I M S

1. A carrier medium to retain a biofilm in a fluid, e.g. waste water, comprising a number of carrying elements having  
5 close-set pores, c h a r a c t e r i z e d in that these the carrying elements are formed as thin discs- or ringshaped flakes of a relatively hard material.
2. A carrier medium according to claim 1, c h a r a c t e r i  
10 z e d in that the material is a plast.
3. A carrier medium according to claim 1 or 2, c h a r a c t  
e r i z e d in that the flakes are essentially flat.
- 15 4. A carrier medium according to claim 1,2.or 3. c h a r a c t  
e r i z e d in that the flakes has a thickness between 0.1 and 2.0 mm.
5. A carrier medium according to any of the claims 1 - 4, c h  
20 a r a c t e r i z e d in that the flakes are round and have a diameter between 2 and 50 mm.
6. A process for the production of a carrier medium to retain a biofilm in a fluid, e.g. waste water, comprising a number of  
25 bodies as have close-set pores and are formed as thin discs- or ringshaped flakes of a relatively hard plast, c h a r a c  
t e r i z e d in that the plast material, in the shape of a granulate or a powder, is mixed with a foaming detergent, whereafter the mixture is led to an extruder and heated in  
30 such a way that the plast material is brought into a plastic condition while the foaming detergent by foaming up is filling the material with cells under a gas overpressure, and the foamed plast material then is extruded from the nozzle of the extruder to a bar cooled to a partly plastic condition and  
35 cutted into discs so thin that, at any rate, a great part of

the cells behind the cuts are bursted by the overpressure of the gas.

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## AMENDED CLAIMS

[received by the International Bureau on 23 February 1996  
original claims 1-6 replaced by amended claims 1-5 ( 1 page )]

- 5 1. A carrier medium to retain a biofilm in a fluid, e.g. waste water, comprising a number of carrying elements having close-set pores, c h a r a c t e r i z e d in that these the carrying elements are formed as thin discs- or ringshaped flakes of a relatively hard plast.
- 10 2. A carrier medium according to claim 1, c h a r a c t e r i z e d in that the flakes are essentially flat.
3. A carrier medium according to claim 1 or 2, c h a r a c t e r i z e d in that the flakes have a thickness between 0.1 and 2.0 mm.
- 15 4. A carrier medium according to any of the claims 1, 2 or 3, c h a r a c t e r i z e d in that the flakes are round and have a diameter between 2 and 50 nm.
- 20 5. A process for the production of a carrier medium to retain a biofilm in a fluid, e.g. waste water, comprising a number of bodies as have close-set pores and are formed as thin discs- or ringshaped flakes of a relatively hard plast, c h a r a c t e r i z e d in that the plast material, in the shape of a granulate or a powder, is mixed with a foaming detergent, whereafter the mixture is led to an extruder and heated in such a way that the plast material is brought into a plastic condition while the foaming detergent by foaming up is filling the material with cells under a gas overpressure, and the foamed plast material then is extruded from the nozzle of the extruder to a bar cooled to a partly plastic condition and cutted into discs so thin that, at any rate, a great part of the cells behind the cuts are bursted by the overpressure of the gas.
- 30 35

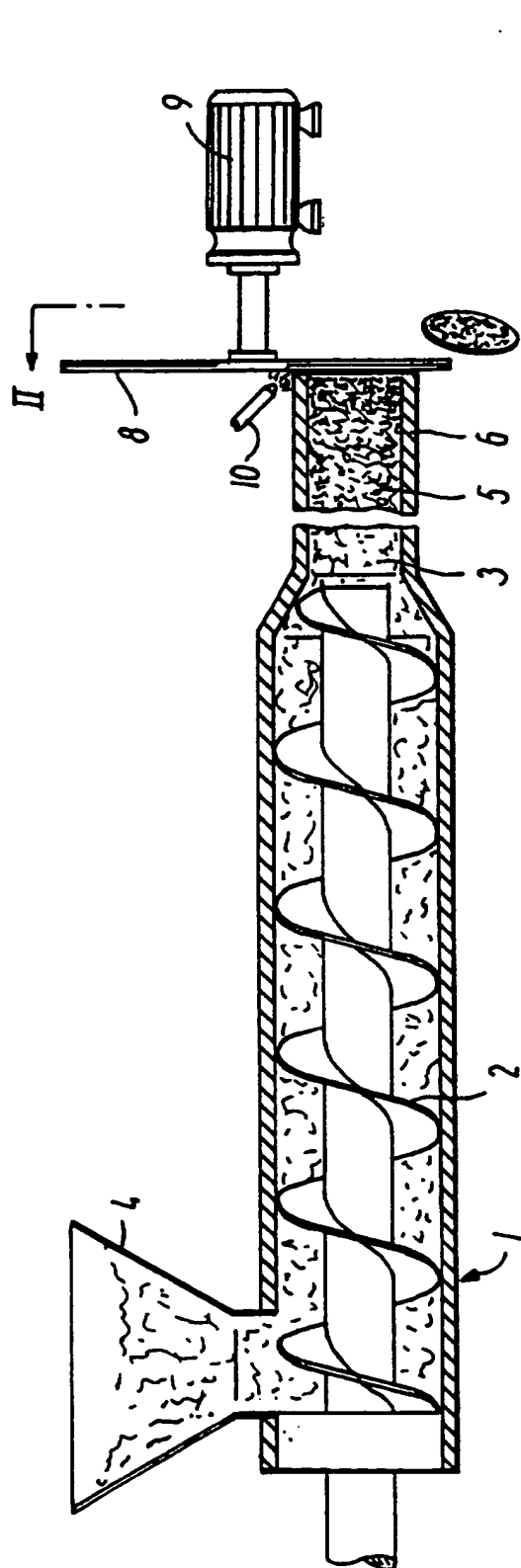


FIG. 1

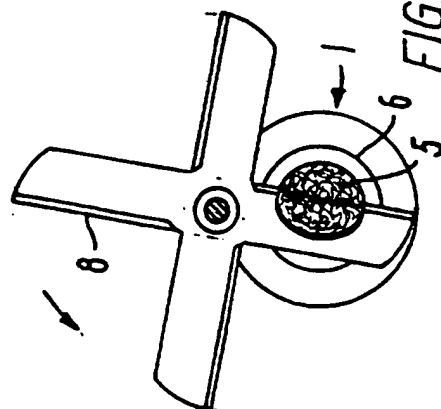


FIG. 2

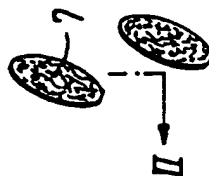


FIG. 3

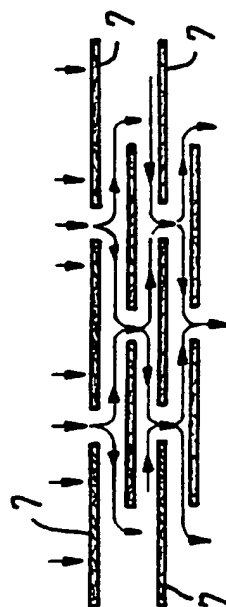


FIG. 4

1  
**INTERNATIONAL SEARCH REPORT**

International application No.  
**PCT/DK 95/00393**

**A. CLASSIFICATION OF SUBJECT MATTER**

**IPC6: C02F 3/10, B01J 19/30, C12M 1/14, B29C 47/00**  
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

**IPC6: B01J, B29C, C02F, C12M**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**SE,DK,FI,NO classes as above**

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0302965 A2 (MANVILLE CORPORATION), 15 February 1989 (15.02.89), page 5, line 18; page 5, line 38 - line 39, claim 1  --	1
A	WO 8400901 A1 (ERIKSSON, HANS), 15 March 1984 (15.03.84), page 2, line 1 - line 10, claims 1-3  --	1-6
A	EP 0477831 A1 (WORTHINGTON, ANDREW DAVID), 1 April 1992 (01.04.92), claims 1,4  --	1-4
A	DE 4022552 A1 (ZIRKENBACH, HORST), 23 January 1992 (23.01.92), claims 1-2  -- -----	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search

**30 January 1996**

Date of mailing of the international search report

**31 -01- 1996**

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

05/01/96

International application No.

PCT/DK 95/00393

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